Back to Basics --

Using Hydrology to Develop Solutions

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Discussion Overview
Points to look for …

⭐ **Problem Solving Framework**
- ✓ *Practical approaches*
- ✓ *Partnerships*

⭐ **Targeted Activities**
- ✓ *Contributing areas*
- ✓ *Delivery mechanisms*
- ✓ *Hydrology & duration curves*

⭐ **Adaptive Management**
- ✓ *Connecting the pieces*

Watershed Plan Key Elements
Regulatory Considerations

⭐ **§319 Guidance**
- ✓ Source Identification
- ✓ Management Measures, Load Reductions, Critical Areas
- ✓ Needed Technical & Financial Assistance
- ✓ Information / Education Component
- ✓ Schedule
- ✓ Measurable Milestones
- ✓ Assessment Framework & Criteria
- ✓ Effectiveness Monitoring

TMDL Development
Regulatory Considerations

⭐ **Applicable WQ Standards**

⭐ **Loading Capacity**

⭐ **Source Assessment**

⭐ **Allocations**

⭐ **Seasonal Variation**

⭐ **Margin of Safety**
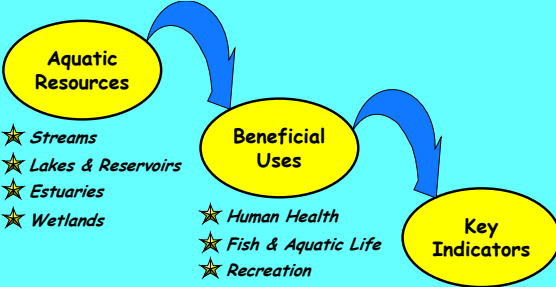

Watershed Plan Development
Problem Solving Framework

⭐ **Practical approach using key questions …**

✓ _WHY_ the concern

✓ _WHAT_ reductions are needed

✓ _WHERE_ are the sources

✓ _WHO_ needs to be involved

✓ _WHEN_ will actions occur

WHY the Concern
Identifying Objectives

Aquatic Resources

Beneficial Uses

Key Indicators

⭐ _Streams_
⭐ _Lakes & Reservoirs_
⭐ _Estuaries_
⭐ _Wetlands_

⭐ _Human Health_
⭐ _Fish & Aquatic Life_
⭐ _Recreation_

WHY the Concern
Key Indicators

✔ **Water Column**

✔ **Sediment**

✔ **Aquatic Organisms**

✔ **Flow**

✔ **Channel Characteristics**

✔ **Riparian Conditions**

WHAT Reductions are Needed
Challenges

⭐ *Wide array of concerns +++*
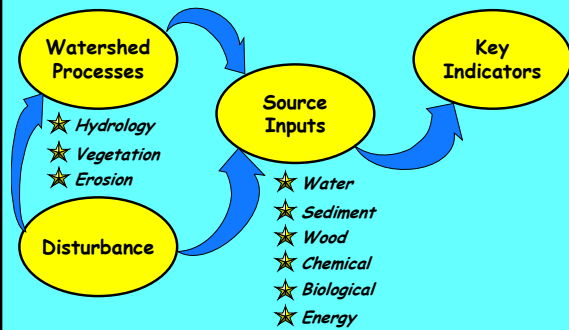   *limited time, data, methods, resources*

Silviculture

Urban

Agriculture

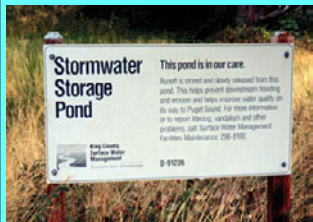## WHERE are the Sources
"Bottom-up" Focus

Watershed Processes

Source Inputs

Key Indicators

⭐ *Hydrology*
⭐ *Vegetation*
⭐ *Erosion*

Disturbance

⭐ *Water*
⭐ *Sediment*
⭐ *Wood*
⭐ *Chemical*
⭐ *Biological*
⭐ *Energy*

WHERE are the Sources
Hazard / Delivery

WHO Needs to be Involved
Partnerships

⭐ **Treatment**

WHO Needs to be Involved
Partnerships

⭐ **Restoration / Protection**
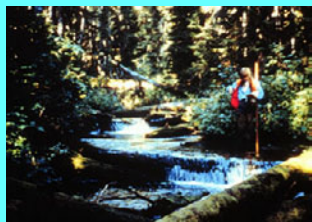
Hydrology-Based Framework
Duration Curves

⭐ **Pioneered by Kansas**
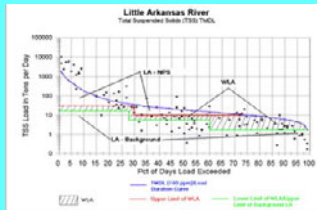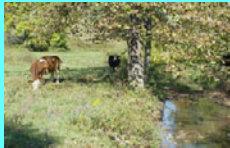
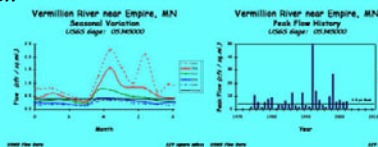
Hydrology-Based Framework
Some Basic Concepts

✓ *Daily Average Flows*

✓ *Seasonal Patterns*

✓ *Annual Variation*

✓ *Frequency Distributions*
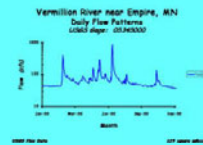
Flow Duration Curves
Nuts & Bolts

⭐ **Based on Cumulative Frequency Distribution**

✓ *Historic hydrologic record -- daily average flows*
  [e.g. download from USGS NWIS-Web]

✓ *Developed with statistical software or spreadsheet*
  [e.g. =PERCENTILE(a1:a3650,0.5) in Excel]

✓ *Can also look at other key recurrence intervals*
  [e.g. median flow, 2-year peak, 7Q10]

Flow Duration Curves
Basic Form

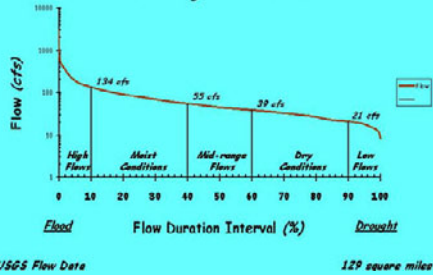**Vermillion River near Empire, MN**
Flow Duration Curve
USGS Gage: 05345000

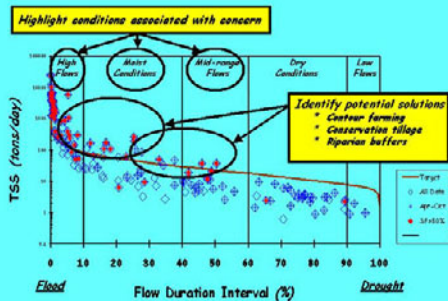## Water Quality Duration Curves
Concept

⭐ **Again, use Cumulative Frequency Distribution**

  ✓ *Y-axis becomes water quality parameter value*
      [e.g. load or concentration]

  ✓ *X-axis position matches flow recurrence interval*

  ✓ *Curve determined by target concentration <u>and</u>*
      flow associated with recurrence interval

Load Duration Curves
Basic Form

Duration Curves
Basics

⭐ **Method offers a number of advantages**

✓ *Provides context for looking at WQ data*

✓ *Considers full range of flows* (not just a design point)

✓ *Offers framework to target options*

✓ *Easier to explain -- simple display*

Duration Curves
Advantages

✓ **Context to interpret monitoring data**
   (modeling data as well)

✓ **Help guide implementation**

   - Targeted *Participants*

   - Targeted *Programs*

   - Targeted *Activities*

   - Targeted *Areas*

Water Quality Patterns
Watershed Condition -- Hydrologic

Pipe Creek below Elfton
Sample Load Duration Curve

E.Coli (#/day)

High Flows | Moist Conditions | Mid-range Flows | Dry Conditions | Low Flows

Flood   Flow Duration Interval (%)   *Drought*

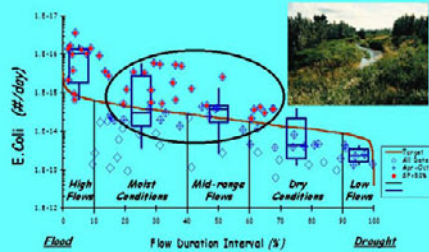TARGETED Participants: *Point Sources*
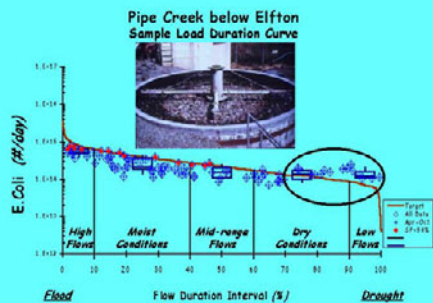
Water Quality Patterns
Contributing Areas

Willow Creek near Turkey Gap
Sample Load Duration Curve
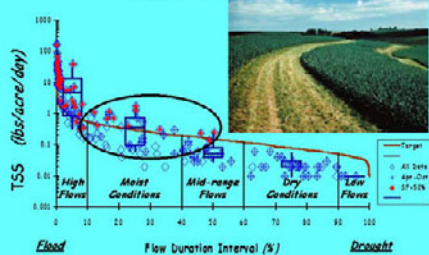
TARGETED Programs: Riparian Buffers (e.g. CRP, CREP)

Water Quality Patterns
Contributing Areas

Chicken Run above Mt. Pleasant
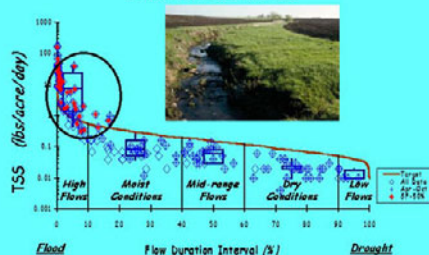Sample Yield Duration Curve

TARGETED Activities: Contour Strips, Conservation Tillage

Water Quality Patterns
Delivery Mechanisms

Rock Creek near Moose Junction
Sample Yield Duration Curve

TARGETED Areas: Streambank Erosion, Bank Stability

Hydrology-Based Framework
Duration Curves

⭐ **Support watershed planning through …**

✓ *Enhanced description of water quality concerns*

✓ *Improve basic understanding of key processes*

✓ *Focus on solution development*

Hydrology-Based Framework
Expanded Characterization
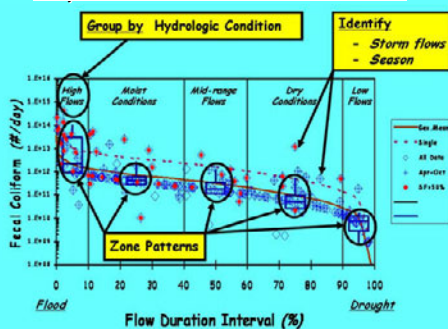
Hydrology-Based Framework
Enhanced Assessment

⭐ **Other potential opportunities …**

✓ *Provide view beyond "Status & Trends"*

✓ *Expand watershed characterization*

✓ *Use with volunteer monitoring efforts*

✓ *Linkage to other analytical methods (e.g. models, Bacteria Source Tracking)*

Hydrology-Based Framework
Beyond "Status & Trends"

⭐ At first glance, a large gap …

Conodoguinet Creek
Time Series
Site ID: 01570000

USGS Water Quality Data
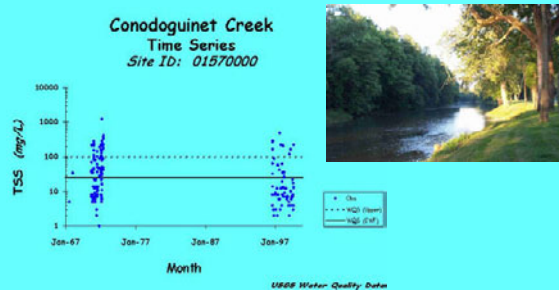
Hydrology-Based Framework
Beyond "Status & Trends"

⭐ LDCs put focus on range of flows …

General Conditions of Concern
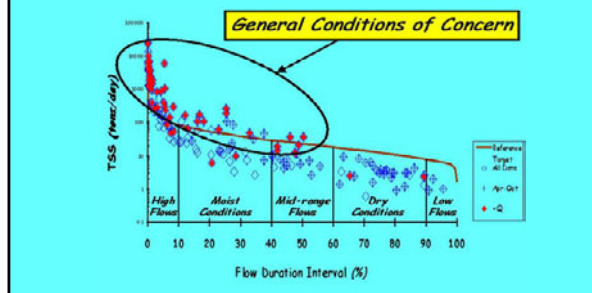
Expanded Characterization
Recognizing Key Watershed Processes

⭐ Importance of watershed size …
√ Smaller ==> flashier at high flows; drier at low flows

Comparison: Clifty, Sand, & E.F. White

Larger watershed w/ sustained baseflow
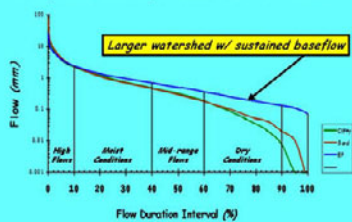
Expanded Characterization
Recognizing Key Watershed Processes

Flow Duration Curve Zone Summary (mm)						
Site Name	1-day	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Au Sable	2.00	1.195	0.880	0.712	0.603	0.479
Little Eagle	22.40	3.576	0.777	0.299	0.117	0.027

Hydrology-Based Framework
Use with Volunteer Monitoring Data

⭐ **Reference watershed**
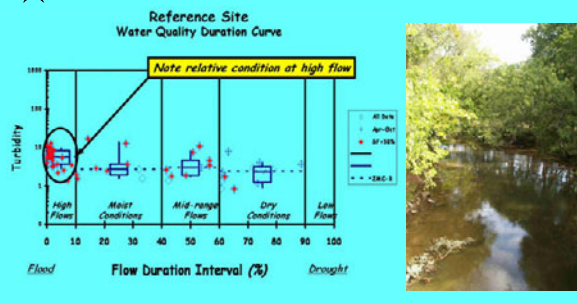
Hydrology-Based Framework
Use with Volunteer Monitoring Data

⭐ **Provides feedback opportunities …**

Fourmile Run

Hydrology-Based Framework
Monitoring & Assessment

⭐ **Example**:   *Fourmile Run*

Fourmile Run – Route #120 *(Glebe Road)*
Load Duration Curve
Site: 1AFOU001.92

Monitoring & Assessment
Analysis of Model Output

Catstooth Creek
Load Duration Curve *(Ambient WQ Monitoring Data)*

Monitoring & Assessment
Analysis of Model Output
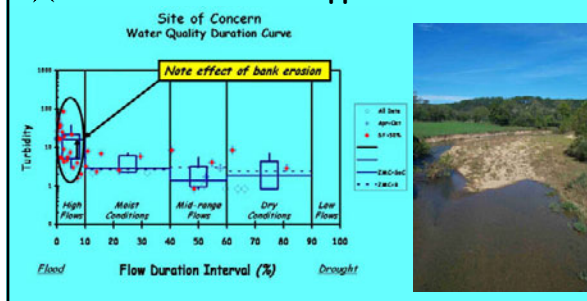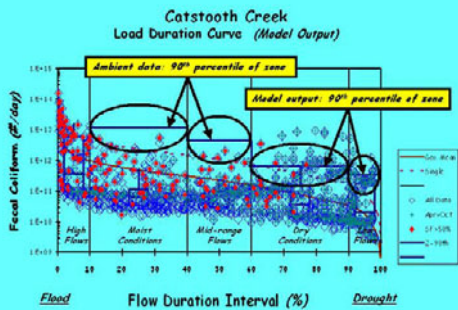
Catstooth Creek
Load Duration Curve (Model Output)

Monitoring & Assessment
Analysis of Model Output

Catstooth Creek
Load Duration Curve (Ambient WQ Monitoring Data)
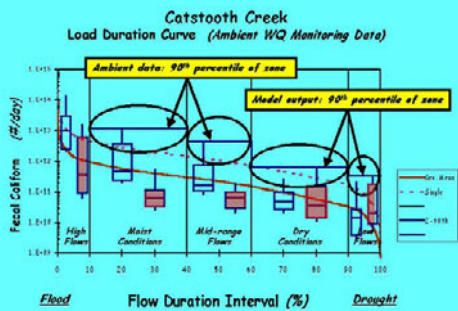
Monitoring & Assessment
Analysis of Bacteria Source Tracking Data

Spots Run
Modified LDC (Ambient WQ Monitoring Data with BST)
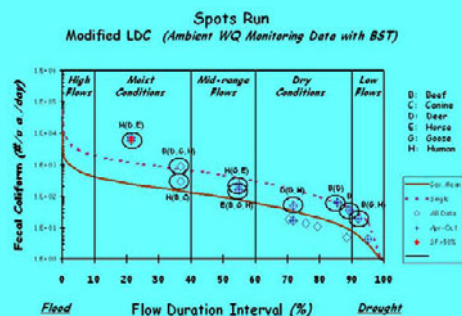
Problem Solving Framework
Highlight "Lessons Learned"

⭐ **Convert WQ Data to INFORMATION**

✓ *Prioritizing Areas of Concern*

✓ *Connecting the Pieces*

✓ *Implementation Focus*

WHERE are the Sources
Prioritizing Assessment Efforts

Lake Fork near Cornland
WQ Duration Curve *(1972 - 2004: May to October)*
Site: EIG 01

Higher concentrations associated with runoff events
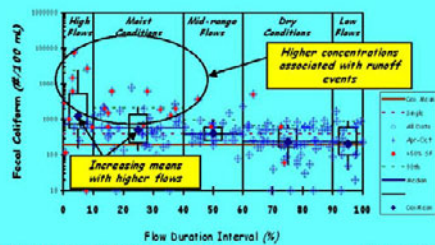
Increasing means with higher flows

Fecal Coliform (#/100 ml)

Flow Duration Interval (%)

IEPA Data & Gage 05579500 Duration Interval   214 square miles

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WHERE are the Sources
Potential Source Areas

EXAMPLE	Duration Curve Zone				
Contributing Source Area	High	Moist	Mid-Range	Dry	Low
Point source				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
CSO's	H	H	H		
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

Note: *Potential relative importance of source area to contribute loads under given hydrologic condition (H: High;   M: Medium;   L: Low)*

WHO Needs to be Involved
Connecting the Pieces

⭐ **Focus:** *Source Areas & Delivery Mechanisms*

⭐ **Example:** *Agricultural Erosion Control*

  ✓ *Agricultural Fields* *(e.g. residue management, crop cover)*

  ✓ *Channel Erosion* *(e.g. channel stabilization, bank protection)*

Connecting the Pieces
Agricultural Fields

⭐ **Targeted Activities**
  ✓ *Residue Management*
  ✓ *Crop Rotation & Cover*
  ✓ *Critical Area Planting*

⭐ **Calculation**
  ✓ *Contributing Area*
  ✓ *Delivery Ratio*

Connecting the Pieces
Channel Erosion

⭐ **Targeted Activities**
  ✓ *Bank Protection*
  ✓ *Channel Stabilization*
  ✓ *Critical Area Planting*

⭐ **Calculation**
 ✓ *Channel Dimensions*
  ✓ *Lateral Recession Rate*

Connecting the Pieces
Developing Solutions

⭐ **Focus:** *Potential Management Practices*

EXAMPLE	Duration Curve Zone				
Source Area	High	Moist	Mid-Range	Dry	Low
Point source controls	L	L	M	H	H
Septic system inspection	M	M-H	H	H	H
CSO repair / abatement	H	H	H		
SSO repair / abatement			M	H	H
Riparian buffers		H	H	H	
Pasture management	H	H	M		
Pet waste education & ordinances		M	H	H	
Hobby farm livestock education & ordinances		H	H	M	
		Potential for effective load reductions under given hydrologic condition			

Connecting the Pieces
Developing Solutions

⭐ **Erosion Control Actions**

Kickapoo Creek at Waynesville
WQ Duration Curve *(1975 - 2004: April to October)*
Site: EIE 04

Connecting the Pieces
Developing Solutions
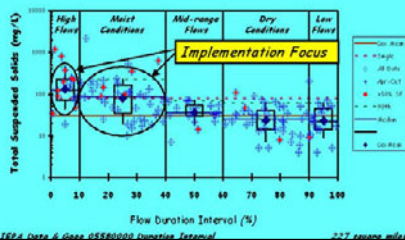
⭐ **Erosion Control Actions**

✓ *Cover crops*

✓ *Buffer strips*

✓ *Conservation tillage*

✓ *Stormwater management*

✓ *Non-row crop alternatives*

✓ *Construction site runoff*

Connecting the Pieces
Allocation Development

Connecting the Pieces
Allocation Development

⭐ **Targeted Activities**
- ✓ *Separation*
- ✓ *Storage Basins*
- ✓ *Tunnels*
- ✓ *Treatment Basins*

⭐ **Calculation**
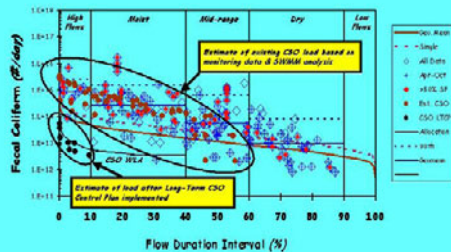- ✓ *SWMM Modeling*

Connecting the Pieces
"The Challenge"

Hydrology-Based Framework
Connecting the Pieces

Crooked River at Freedom Bend
Load Duration Curve *(1974 - 1995 Monitoring Data)*

Hydrology-Based Framework
Developing Solutions

⭐ **Components** *plus* **Implementation Considerations**

TMDL SUMMARY	Loads expressed as *(cfu/day)*				
	High	Moist	Mid-Range	Dry	Low
Reduction	92%	90%	79%	41%	0%
TMDL	1.39E+14	5.09E+13	2.37E+13	1.15E+13	5.09E+12
Load Allocations	9.32E+12	2.73E+12	2.26E+13	1.05E+13	4.22E+12
Wasteload Allocations	4.68E+11	4.68E+11	4.68E+11	4.68E+11	4.68E+11
CSO	1.25E+14	4.58E+13	0.00E+00	0.00E+00	0.00E+00
Margin of Safety	4.11E+12	1.89E+12	6.20E+11	4.99E+11	4.06E+11
Implementation	Long Term CSO Plan		Municipal NPDES		
Opportunities			Riparian Protection		
			Pet Waste Ordinance		
			Stormwater Mgt.		

Hydrology-Based Framework
Lunch Time

⭐ **Driving Principles**

✓ *Technically-based (logic path)*

✓ *Meaningful (easily understood)*

✓ *Value-added (connect to implementation efforts designed to solve problem)*

✓ *...*

✓ *...*